

APPLICATION FOR UNITED STATES LETTERS PATENT

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INVENTION: SPUTTERING TARGET FOR PRODUCTION
 OF MAGNETIC RECORDING MEDIUM,
 METHOD FOR PRODUCING MAGNETIC
 RECORDING MEDIUM USING SAME, AND
 MAGNETIC RECORDING MEDIUM

S P E C I F I C A T I O N

This application is based on Japanese Patent Application No. 2000-46471 filed February 23, 2000, the content of which is incorporated hereinto by reference.

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BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

This invention relates to a sputtering target for
10 production of a magnetic recording medium, which is used
for film formation of a magnetic layer of the magnetic
recording medium mounted in various magnetic recording
devices, including external storage devices of computers.
The invention also relates to a method for producing a
15 magnetic recording medium by use of the sputtering target,
and a magnetic recording medium produced by this method
for production.

Hereinafter, the sputtering target will be referred
to simply as a "target".

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DESCRIPTION OF THE RELATED ART

Various compositions and structures of a magnetic
layer and various materials for a nonmagnetic undercoat
25 layer have been proposed for a magnetic recording medium
required to have a high recording density and a low noise.
In recent years, a proposal has been made for a magnetic

layer, generally called a granular magnetic layer, which has a structure comprising magnetic crystal grains surrounded with a nonmagnetic nonmetallic substance such as an oxide or a nitride.

5 The granular magnetic layer is considered to obtain low noise characteristics for the following reason: A nonmagnetic nonmetallic grain boundary phase physically separates the magnetic grains. Thus, the magnetic interaction between the magnetic grains lowers to suppress
10 the formation of zigzag domain walls occurring in a transition region of recording bits.

 Examples using the granular magnetic layer are shown in Japanese Patent Application Laid-open No. 8-255342 (1996) and U.S. Patent No. 5,679,472. Japanese Patent
15 Application Laid-open No. 8-255342 (1996) proposes the achievement of a low noise by laminating a nonmagnetic film, a ferromagnetic film, and a nonmagnetic film sequentially, and then heat treating the laminate to form a granular recording layer comprising ferromagnetic crystal grains
20 dispersed in the nonmagnetic film. In this case, a silicon oxide or nitride is used as the nonmagnetic film.

 U.S. Patent No. 5,679,473 describes that RF sputtering is performed with the use of a CoNiPt target incorporating an oxide such as SiO_2 , whereby there can be
25 formed a granular recording layer having a structure comprising magnetic crystal grains surrounded by a nonmagnetic oxide and thereby individually separated. As

a result, a magnetic recording medium having high Hc (coercive force) and a low noise is obtained. The method described in U.S. Patent 5,679,473, for film formation of a granular magnetic layer by performing RF sputtering using
5 a CoNiPt target incorporating an oxide such as SiO₂, can produce a magnetic recording medium without involving process such as heat treatment, and is thus excellent in mass producing ability.

However, when a target having an oxide dispersed in
10 a metal is sputtered, abnormal discharge due to charging of oxide particles, as an insulating material, at the start of sputter discharging tends to occur. When abnormal discharge occurs, the surface of the target is partially heated, and thus melts and flies. As a result, oxide
15 particles measuring several micrometers may adhere onto a magnetic recording medium disposed at an opposed position.

If the oxide particles thus adhere onto the magnetic recording medium, the incident that the particles collide
20 with the head arises. To prevent this incident, the particles may be removed by sliding, for example, a cleaning tape over the medium having the film formed by sputtering. This sliding treatment peels not only the particles, but also the magnetic layer and a protective
25 layer, causing problems such as signal defects or corrosion.

Japanese Patent 2948019 describes that the particle

diameter of an insulating substance is set at 20 μm or less in order to resolve abnormal discharge occurring when sputtering is performed using a sputtering target comprising a sintered mixture of the insulating substance and a conductive substance. However, this sputtering target is used for film formation of a heating resistor thin film of a thin film thermal head. It has been unknown whether the sputtering target can be used for film formation of a magnetic layer of a magnetic recording medium because of its magnetic characteristics, for example.

SUMMARY OF THE INVENTION

Extensive studies have been conducted to prevent the foregoing abnormal discharge and adhesion of oxide particles onto a magnetic recording medium. By controlling the particle diameter of an oxide incorporated into a target for providing a magnetic layer, it has been found that abnormal discharge can be suppressed, and adhesion of oxide particles onto a magnetic recording medium can be prevented.

In the first aspect of the present invention, a sputtering target for film formation of the magnetic layer of a magnetic recording medium comprising at least a nonmagnetic undercoat layer, a magnetic layer, and a protective layer laminated sequentially on a nonmagnetic

substrate comprises a mixture of a metal and an oxide, wherein a particle diameter of the oxide being 10 μm or less.

Here, the particle diameter of the oxide may be 5
5 μm or less.

The mixture may comprise an alloy containing at least Co and Pt, and at least one oxide selected from the group consisting of oxides of Si, Ti, Zr, Al and Cr.

In the second aspect of the present invention, a
10 method for producing a magnetic recording medium comprising at least a nonmagnetic undercoat layer, a magnetic layer, and a protective layer laminated sequentially on a nonmagnetic substrate, comprises the step of forming the magnetic layer by RF sputtering of a
15 sputtering target for the magnetic recording medium, wherein the sputtering target for the magnetic recording medium comprises a mixture of a metal and an oxide, and a particle diameter of the oxide in the sputtering target is 10 μm or less.

20 Here the particle diameter of the oxide in the sputtering target is may be 5 μm or less.

The sputtering target may be a mixture comprising an alloy containing at least Co and Pt, and at least one oxide selected from the group consisting of oxides of Si,
25 Ti, Zr, Al and Cr.

In the third aspect of the present invention, a magnetic recording medium comprising at least a

nonmagnetic undercoat layer, a magnetic layer, and a protective layer laminated sequentially on a nonmagnetic substrate, where the magnetic layer is a granular magnetic layer having a structure in which crystal grains containing
5 Co and having ferromagnetism are surrounded with oxide grain boundaries, the magnetic layer has been obtained by RF sputtering of a sputtering target for a magnetic recording medium, the sputtering target comprising a mixture of a metal and an oxide, the oxide having a particle
10 diameter of 10 μm or less, and defects attributed to particles of the oxide and measuring 0.05 μm or more are not present on a surface of the magnetic recording medium.

According to the present invention, a magnetic layer is formed by RF sputtering of the above-described
15 sputtering target, whereby a granular magnetic layer having excellent magnetic characteristics and electromagnetic conversion characteristics can be formed by a simple process. Furthermore, the invention is free from the problem of adhesion of oxide particles onto a
20 magnetic recording medium.

The above and other objects, effects, features and advantages of the present invention will become more apparent from the following description of embodiments thereof taken in conjunction with the accompanying
25 drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic sectional view of a magnetic recording medium according to the present invention;

FIGS. 2A and 2B are SEM (scanning electron
5 microscope) images of the surface of a target used, in which
FIG. 2A shows the target with an SiO_2 particle diameter
of 10 μm or less according to the present invention, while
FIG. 2B shows the target with an SiO_2 particle diameter
of more than 50 μm , as a comparative example;

10 FIG. 3 shows an SEM image of foreign objects adhering
onto the surface of a magnetic recording medium when a
magnetic layer was formed using the target with an SiO_2
particle diameter of more than 50 μm , the target shown in
FIG. 2B; and

15 FIG. 4 shows the results of EDX (energy dispersive
X-ray diffraction) analysis of foreign objects adhering
onto the surface of the magnetic recording medium when the
magnetic recording medium was prepared using the target
with an SiO_2 particle diameter of more than 50 μm , the target
20 shown in FIG. 2B.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

The present invention will now be described in more
25 detail with reference to the accompanying drawings.

A sputtering target according to the present
invention is used for film formation of a magnetic layer

of a magnetic recording medium as an embodiment of the present invention as described in FIG. 1. FIG. 1 is a schematic sectional view of a magnetic recording medium showing an embodiment of the present invention. The
5 numeral 1 denotes a nonmagnetic substrate, 2 a nonmagnetic undercoat layer, 3 a magnetic layer, especially, a granular magnetic layer, 4 a protective layer, and 5 a liquid lubricant layer.

The magnetic recording medium shown in FIG. 1 is
10 obtained by a manufacturing method having the step of providing the nonmagnetic undercoat layer 2 on the nonmagnetic substrate 1, the step of providing the magnetic layer 3 on the nonmagnetic undercoat layer 2, the step of providing the protective layer 4 on the magnetic layer 3,
15 and the step of providing the liquid lubricant layer 5 on the protective layer 4.

As the nonmagnetic substrate 1, there can be used, for example, a NiP-plated Al alloy substrate, glass substrate, or plastic substrate. The step of providing
20 the nonmagnetic undercoat layer 2 on the nonmagnetic substrate 1 is performed by a conventional method such as sputtering. As the nonmagnetic undercoat layer 2, there can be used, for example, Cr or Cr alloy.

The step of providing the magnetic layer 3 on the
25 nonmagnetic undercoat layer 2 is a step for RF sputtering of a target which is a mixture of a metal, especially, a ferromagnetic metal, and an oxide. In the present

invention, it is important that the particle diameter of the oxide in the target be 10 μm or less in order to suppress the adhesion of oxide particles onto the magnetic recording medium. Preferably, the particle diameter of the oxide
5 in the target is made 5 μm or less, whereby the adhesion of oxide particles can be suppressed completely.

The target available on this occasion may be a target of a composition which gives desired magnetic characteristics and electromagnetic conversion
10 characteristics. Preferably, the target is one having the ferromagnetic metal portion which is an alloy at least containing Co and Pt. The oxide added to the alloy is preferably at least one oxide selected from the group consisting of oxides of Si, Ti, Zr, Al and Cr.

15 Then, the protective layer 4 is formed on the magnetic layer 3. The protective layer 4 can be formed by conventional method such as sputtering and CVD. For example, a layer of carbon 3 is used as protective layer 4. Optionally, the liquid lubricant layer 5 consisting
20 of lubricant such as perfluoropolyether is formed on the protective layer 4 by dipping.

In above described matter, magnetic recording medium of the present invention is provided.

In the present invention, the particle diameter of
25 the oxide added to the target used when providing the magnetic layer 3 is made small, as described earlier. By this measure, the degree of charging of the oxide observed

particularly at the start of sputter discharging lowers to a level at which no abnormal discharge occurs. Thus, the oxide particles do not adhere any more onto the surface of the magnetic layer during the formation of the magnetic layer. That is, the magnetic recording medium having the magnetic layer formed with the use of the target in the present invention is free from defects occurring on the medium owing to the oxide particles and measuring 0.05 μm or more.

10 [Examples]

Example 1:

A plurality of smooth-surface crystallized glass substrates (crystallized glass substrates TS-10 of (Kabushiki Kaisha) Ohara Inc., 3.5 inches (88.9 mm), 0.8 mm thick) as a nonmagnetic substrate 1 were readied for use. These glass substrates were washed, and then introduced into a sputtering device to form a pure Cr undercoat layer 2 with a film thickness of 15 nm on each of the glass substrates.

20 Then, a $(\text{CoCr}_{12}\text{Pt}_{12})_{95}-(\text{SiO}_2)_5$ target was subjected to RF sputtering at an Ar gas pressure of 5 mTorr to form a granular magnetic layer 3 with a film thickness of 20 nm. The target used on this occasion for film formation of the magnetic layer was a target containing SiO_2 particles with varying particle diameter.

25 On the magnetic layer, a carbon protective layer 4 with a film thickness of 10 nm was laminated, and the

lamine was taken out of the vacuum. Then, a liquid lubricant was coated to a thickness of 1.5 nm to form a liquid lubricant layer 5. In this manner, a magnetic recording medium configured as shown in FIG. 1 was prepared.

5 Heating of the substrate prior to film formation had not been performed.

FIGS. 2A and 2B are SEM (scanning electron microscope) images of the surface of the target used, in which FIG. 2A shows the surface of the target containing

10 SiO_2 particles having a particle diameter of 5 μm or less, while FIG. 2B shows the surface of the target containing SiO_2 particles having a particle diameter of more than 50 μm . These targets have an equal SiO_2 content of 5%, but the target of A and the target of B are found to be greatly

15 different in the particle diameter of SiO_2 .

FIG. 3 shows an SEM image of foreign objects adhering onto the surface of the magnetic recording medium when the magnetic recording medium was prepared using the target containing SiO_2 particles having a particle diameter of

20 more than 50 μm , the target shown in FIG. 2B. FIG. 4 shows the results of EDX (energy dispersive X-ray diffraction) analysis of the foreign objects shown in FIG. 3. The foreign objects are found to be SiO_x , and have a size of about 10 μm .

25 In each of the magnetic recording media obtained in the above-described manner, the number of the foreign objects adhering onto the magnetic recording medium was

measured with an optical appearance test device. Table 1 shows the particle diameter of SiO_2 contained in the target used when forming the magnetic layer, and the number of the foreign objects adhering onto the magnetic recording medium as the average value of the ten magnetic recording media. For comparison, the results obtained with the use of the target containing no SiO_2 are also shown.

Table 1

Particle diameter of SiO_2 in the target	Number of foreign objects adhering to the medium (number per medium)
Comparison: no SiO_2	1 or less
5 μm or less	1 or less
10 μm or less	2.0
15 μm or less	11
20 μm or less	24
100 μm or less	152

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As shown in Table 1, when the particle diameter of SiO_2 is more than 10 μm , many foreign objects are detected on the magnetic recording medium. At a particle diameter of 10 μm or less, the number of foreign objects sharply decreases, and few foreign objects are detected at a particle diameter of 5 μm or less. Thus, controlling the particle diameter of SiO_2 added to the target is found to prevent the adhesion of foreign objects onto the medium. Example 2:

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Magnetic recording media were prepared in exactly

the same manner as described in Example 1, except that a $(\text{CoCr}_7\text{Pt}_{12})_{97}-(\text{Cr}_2\text{O}_3)_3$ target having different particle diameters was used as a target for formation of a magnetic layer.

5 In each of the magnetic recording media obtained in the above-described manner, the number of foreign objects adhering onto the magnetic recording medium was measured with an optical appearance test device. Table 2 shows the particle diameter of Cr_2O_3 contained in the target used when
10 forming the magnetic layer, and the number of the foreign objects adhering onto the magnetic recording medium as the average value of the ten magnetic recording media. For comparison, the results obtained with the use of the target containing no Cr_2O_3 are also shown.

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Table 2

Particle diameter of Cr_2O_3 in the target	Number of foreign objects adhering to the medium (number per medium)
Comparison: no Cr_2O_3	1 or less
5 μm or less	1.2
10 μm or less	1.9
20 μm or less	19
100 μm or less	255

Table 2 shows that as in the case of the SiO_2 containing target shown in Table 1, when the particle
20 diameter of Cr_2O_3 is more than 10 μm , many foreign objects

are detected on the magnetic recording medium. At a particle diameter of 10 μm or less, the number of foreign objects sharply decreases, and few foreign objects are detected at a particle diameter of 5 μm or less.

5 As discussed above, in connection with the target incorporating the oxide in the ferromagnetic alloy, the target used when forming a granular magnetic layer, the particle diameter of the oxide is controlled to 10 μm or less, preferably 5 μm or less, according to the present
10 invention. By this measure, abnormal discharge during sputtering can be suppressed, and adhesion of oxide particles to the medium can be inhibited. The so controlled target is RF sputtered to form a granular magnetic layer. As a result, an excellent magnetic
15 recording medium free from defects or corrosion can be produced by a simple process.

 The present invention has been described in detail with respect to preferred embodiments, and it will now be apparent from the foregoing to those skilled in the art
20 that changes and modifications may be made without departing from the invention in its broader aspects, and it is the intention, therefore, in the appended claims to cover all such changes and modifications as fall within the true spirit of the invention.